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US-A- 4 169 818
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US-A- 4 861 500(73) Proprietor: **CONOCO INC.**
1000 South Pine Street
Ponca City
Oklahoma 74603 (US)

Proprietor: **E.I. DU PONT DE NEMOURS AND COMPANY**
1007 Market Street
Wilmington
Delaware 19898 (US)

(72) Inventor: **Cantu, Lisa A.**
3105 Cadet Road

Ponca City,
Oklahoma 74604 (US)
Inventor: **McBride, Edward F.**
2927 Faulkland Road
Wilmington,
Delaware 19808 (US)
Inventor: **Osborne, Marion**
6003 Bermuda Dunes Drive
Houston,
Texas 77069 (US)

(74) Representative: **Woodman, Derek et al**
Frank B. Dehn & Co.
European Patent Attorneys
Imperial House
15-19 Kingsway
London WC2B 6UZ (GB)

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EP 0 404 489 B1

Description

Background of the Invention

This invention relates to a process for completing or working over a well penetrating a subterranean formation such as an oil and/or gas producing formation.

By definition a completion or workover fluid is a fluid that is placed against the producing formation while conducting such operations as well killing, cleaning out, drilling in, plugging back, controlling sand, or perforating. Basic fluid functions are to facilitate movement of treating fluids to a particular point downhole, to remove solids from the well, and to control formation pressures.

Required fluid properties vary depending on the operation, but the possibility of formation damage is always an important concern. In certain operations, such as gravel packing or perforating, sand-face or perforation plugging is a prime concern. In recent years many new fluid systems have appeared, most due to the recognition of the high risk of reducing the productivity, or completely plugging certain sections of the producing zone, through contact with a foreign fluid. US 4169818 to DeMartino describes a well treatment hydraulic fluid composition which comprises an aqueous medium which is thickened with a mixture of hydroxypropylcellulose and poly(maleic anhydride/alkyl vinyl ether) as a gelling agent.

Fluid density should be no higher than needed to control formation pressure. With reasonable precautions a hydrostatic pressure of 100-200 psi (0.69-1.4 MPa) over formation pressure is adequate. Balanced or slightly underbalanced pressure workovers are ideal from the standpoint of formation damage and, with proper equipment to contain the surface pressure, are practical for some operations.

Fluid loss characteristics of the treatment fluid are, tailored to prevent loss of excessive quantities of fluid to the formation, or to permit application of "hydraulic stress" to an unconsolidated sand formation. Bridging at the formation face by properly sized acid-soluble particles (calcium carbonate) is a conventional approach to fluid loss control. In some cases, oil soluble resin particles have been used in place of calcium carbonate. In either case colloidal particles are also required for an effective seal.

Viscosity-related characteristics, such as yield point, plastic viscosity, and gel strength, can be tailored to provide fluid lifting capacity required to bring sand to the surface at reasonable circulating rates. In some cases viscosity builders cause permanent reduction in permeability. This can be minimized by careful polymer selection along with adequate fluid loss control to limit invasion.

In a typical treatment fluid, a fluid viscosity builder is provided to control fluid loss. Viscosity builders such as hydroxyethyl cellulose or other hydrolyzable polymer are commonly used, and typically result in formation of a gel filter pad covering all or part of the treated formation. When a solid fluid loss additive such as particles of calcium carbonate is included in the fluid, it is generally necessary to carry out an acid treatment to dissolve the particles and to restore formation permeability.

Unbroken hydroxyethyl cellulose gel, even in the absence of calcium carbonate particles, can cause significant permeability reduction even after backflow. The possibility of permanent permeability loss from invasion of viscosity builders into the formation dictates that proper bridging particles should be used. Unfortunately, the most commonly used material, calcium carbonate, must be removed after the treatment by acidizing. Even with acidizing, some permanent damage is possible. The acid treatment also results in breaking of the gel in the gel filter pad, but in some cases additional gel-breaking treatment is required.

Summary of the Invention

According to the present invention, condensation products of the type described in U.S. Patent 4,715,967 to Bellis et al. are utilized in a completion or workover fluid to provide fluid loss properties and to also provide gel breaking capabilities such that the gel filter pad comprised of condensation product and concentrated gel on the wellbore surface is essentially completely removed, thereby restoring full permeability for the well.

Description of the Preferred Embodiment

The process of this invention basically is a well treatment procedure (but not including formation fracturing) utilizing as the treatment fluid an aqueous gel with a specific particulate fluid loss additive in a specific amount.

The fluid loss additives in the present invention comprise inexpensive, low molecular weight condensation products of hydroxyacetic acid with itself or with compounds containing other hydroxy-, carboxylic-acid- or hydroxycarboxylic-acid moieties. The condensation products are friable solids with a melting point of about 160°C or higher and are substantially crystalline at both ambient and wellbore temperatures. They have a number average molecular weight of 200 to 4000 and preferably are oligomers having a number average molecular weight of about 200 to about 650. They are primarily trimers up through decamers. They are insoluble in both aqueous and hydrocarbon media but

will degrade at specific rates in the presence of moisture and temperatures above about 50°C to form oil- and/or water-soluble monomers and dimers. Rate of hydrolysis at a given temperature can be increased by incorporating small amounts of other molecules (usually less, than 15% by weight) into the hydroxyacetic acid condensation reaction. These other molecules are usually flexible or more bulky than hydroxyacetic acid and partially disrupt crystallinity but leave the condensation product friable. Thus, the treatment agent can be tailored to adjust the rate of hydrolysis from a few hours to several days by controlling the amount and nature of the crystallinity.

As used herein, the term "hydroxyacetic acid condensation product" refers to a material within the description in the preceding paragraph.

The aqueous gels applicable to the present invention include those formed from the hydrolyzable gelling agents described in U.S. Patent 4,470,915 to Conway. The most commonly used gelling agent, and the preferred one for purposes of this invention, is hydroxyethyl cellulose.

The treatment fluid used in the invention comprises an aqueous gel, preferably substantially completely hydrolyzed, and a particulate solid material comprised at least in part of hydroxyacetic acid condensation product. The amount of condensation product in the completion fluid is at least that amount which, upon degradation, results in substantial removal of the gel filter pad formed during the treatment step. For normal treatments, at least 10 pounds of condensation product per 1,000 gallons (1.2 kg/1000 l) of treatment fluid is necessary. Condensation product concentration in treatment fluid refers to the portion of the treatment fluid to which it is added. It is not unusual to use during the procedure one or more slugs of treatment fluid which do not contain the fluid loss additive.

The particle size distribution for the condensation product depends to some extent on the formation to be treated. The desired average particle size in microns can be estimated as the square root of the formation permeability in millidarcys. Particles from submicron to about 200 microns are typically used, and the desired average particle size for most formations will range from about 10 to about 50, recognizing that particles smaller and larger than the average are present.

The process of this invention can effectively control fluid loss in completion or workover operations, and the acidic degradation products (hydroxyacetic acid monomer and dimer) of the fluid loss additive which are produced as a result of the formation conditions break the gel in the gel filter pad and essentially completely remove the gel filter pad with no permanent formation damage.

The hydroxyacetic condensation products can be utilized as the sole fluid loss additive or in combination with other fluid loss additives. It is only essential that the condensation products be degradable at formation conditions, and that they be used in an amount sufficient to substantially completely break the gel in the gel filter pad which is formed during the treatment. The condensation products, as shown in the aforementioned Bellis et al. patent, can be tailored to suit the conditions in the formation to be treated. The process eliminates the need for a separate gel breaker injection step. Often, a separately injected gel breaker only contacts a small fraction of the gel pad, resulting in less than full potential well productivity or injectivity after the treatment.

The exact amount and type of additive for a particular completion treatment in accordance with the invention will depend on factors such as formation type and temperature, etc. It is essential in carrying out the invention that a condensed hydroxyacetic acid product in the form of finely divided particles be incorporated in a treatment fluid in an amount sufficient to provide sufficient degradation products in a reasonable time at formation conditions to restore formation permeability by breaking the gel in the gel filter pad formed during the treatment step. A typical well completion process utilizing the invention is described in the following example.

Example I

In this example, a well is drilled to a depth of 10,000 feet (3 km). The drilling mud is displaced with seawater and a pressure 100 psi over balance is maintained. A completion fluid comprising filtered seawater with 80 pounds/1000 gallons (9.6 kg/1000 l) hydrated hydroxyethyl cellulose and 20 pounds/1000 gallons (2.4 kg/1000 l) particulate hydroxyacetic acid condensation product (average particle size 20 microns) is pH adjusted to about 6 to facilitate gelling of the hydroxyethyl cellulose. The pH adjusted completion fluid with hydrated gel and particulate condensation product is pumped down hole to displace the seawater, and when the completion fluid is in place the well is perforated in a conventional manner. Displacement of completion fluid into the perforations and/or the formation surface results in formation of a filtercake layer of gel and particulate hydroxyacetic acid condensation product. After the well is stabilized in leakoff, the perforating equipment is removed and the well is ready for the next phase of the completion process. Hydrolysis of the condensation product at formation conditions provides hydroxyacetic acid which breaks the gel in the filtercake without the need for separate addition of a gel breaker or an

acidizing step. The filtercake is thus removed, and the formation is undamaged, so that completion of the well can proceed.

Claims

1. A process for treating a well in a subterranean formation penetrated by a wellbore (not being a process for fracturing a subterranean formation) wherein a well treatment fluid comprising an aqueous gel is pumped down said wellbore as part of a well treatment procedure, wherein a particulate fluid loss additive is included in said well treatment fluid, and wherein a gel filter cake is formed on the surfaces of said wellbore in said formation characterized by utilizing as at least a part of said fluid loss additive a hydroxyacetic acid condensation product having a number average molecular weight of between 200 to 4000, said condensation product being degradable at formation conditions whereby hydroxyacetic acid monomers and dimers are formed, and said condensation product being present in an amount sufficient to provide enough degradation products including hydroxyacetic acid to react with and break the gel in said filter cake and to recover permeability in said formation without the necessity of adding a separate gel-breaking material after formation of said gel filter cake.
2. A process according to claim 1 wherein said gel is hydroxyethyl cellulose.
3. A process according to claim 1 or claim 2 wherein said hydroxyacetic acid condensation product is a condensation product of hydroxyacetic acid with up to 15 weight percent co-condensing compounds containing other hydroxy-, carboxylic-acid-, or hydroxycarboxylic acid moieties, being substantially crystalline at both ambient and wellbore temperatures and having a melting point of about 160 °C or higher and sufficiently high to avoid softening or melting during use and being substantially insoluble in said treatment fluid and degradable in the presence of water at elevated temperature to monomers and dimers which are at least partially soluble in oil or water.
4. A process according to any one of claims 1 to 3 wherein said aqueous gel is fully hydrated prior to being combined with said condensation product.
5. A process according to any one of claims 1 to 4 wherein said fluid loss additive consists es-

sentially of said condensation product.

6. A process according to any one of claims 1 to 5 wherein said condensation product is added in an amount of at least 10 pounds per 1000 gallons (1.2 kg/1000 l) of treatment fluid.
7. A process according to any one of claims 1 to 6 wherein the average particle size of said condensation product is from 10 to 50 microns.

Patentansprüche

1. Verfahren zum Behandeln eines Bohrlochs in unterirdischen Schichten, welche von einem Bohrloch durchzogen sind (kein Verfahren zum Ausbrechen von unterirdischen Schichten), bei dem ein Bohrlochbehandlungsfluid, welches ein wäßriges Gel aufweist, in das Bohrloch nach unten als Teil einer Bohrlochbehandlungsweise gepumpt wird, bei dem ein teilchenförmiger Fluidausfallzusatz in dem Bohrlochbehandlungsfluid enthalten ist, und bei dem ein Gelfilterkuchen an den Oberflächen des Bohrlochs in den Schichten gebildet wird, **dadurch gekennzeichnet**, daß als wenigstens ein Teil des Fluidausfallzusatzes ein Glykolsäurekondensationsprodukt eingesetzt wird, welches ein beziffertes, mittleres Molekulargewicht zwischen 200 und 4.000 hat, das Kondensationsprodukt unter den Schichtenbedingungen abbaubar ist, wodurch Glykolsäuremonomere und -dimere gebildet werden, und das Kondensationsprodukt in einer so ausreichenden Menge vorhanden ist, daß man genügend Abbauprodukte erhält, welche Glykolsäure enthalten, um mit dem Gel in dem Filterkuchen zu reagieren und dieses aufzubrechen und die Permeabilität der Schichten wieder herzustellen, ohne daß die Notwendigkeit besteht, daß man zusätzlich ein gesondertes Gelaufbrechmaterial nach der Bildung des Gelfilterkuchens zugeibt.
2. Verfahren nach Anspruch 1, bei dem das Gel Hydroxyethylcellulose ist.
3. Verfahren nach Anspruch 1 oder 2, bei dem das Glykolsäurekondensationsprodukt ein Kondensationsprodukt aus Glykolsäure mit bis zu 15 Gew.-% kokondensierenden Verbindungen ist, welche andere Hydroxy-Glykolsäure- oder Glykolsäureteile umfassen, welche im wesentlichen sowohl bei Umgebungs- als auch Bohrlochtemperaturen kristallin sind und einen Schmelzpunkt von etwa 160 °C oder höher und so ausreichend hoch haben, daß ein Erweichen oder Erschmelzen während des be-

stimmungsgemäßen Einsatzes vermieden wird und das im wesentlichen im Behandlungsfluid unlöslich und in Anwesenheit von Wasser bei erhöhter Temperatur zu Monomeren und Dimeren abbaubar ist, welche wenigstens teilweise in Öl oder Wasser löslich sind.

4. Verfahren nach einem der Ansprüche 1 bis 3, bei dem das wäßrige Gel vollständig hydratisiert ist, bevor es mit dem Kondensationsprodukt zusammengebracht wird. 10
5. Verfahren nach einem der Ansprüche 1 bis 4, bei dem der Fluidausfallzusatz im wesentlichen das Kondensationsprodukt aufweist. 15
6. Verfahren nach einem der Ansprüche 1 bis 5, bei dem das Kondensationsprodukt in einer Menge von wenigstens 10 pounds per 1.000 Gallons (1,2 kg/1.000 l) des Behandlungsfluids zugegeben wird. 20
7. Verfahren nach einem der Ansprüche 1 bis 6, bei dem die mittlere Teilchengröße des Kondensationsprodukts 10 bis 50 µm ist. 25

Revendications

1. Procédé de traitement d'un puits dans une formation souterraine pénétrée par un forage de puits (qui n'est pas un procédé de fracturation d'une formation souterraine), dans lequel un fluide de traitement de puits, constitué par un gel aqueux, est pompé vers le bas dans ledit forage de puits, comme une partie d'une opération de traitement d'un puits, un réducteur particulaire de filtrat étant contenu dans ledit fluide de traitement du puits, et un cake de filtration constitué de gel étant formé sur les surfaces dudit forage de puits dans ladite formation, caractérisé en ce qu'on utilise, comme au moins une partie dudit réducteur de filtrat, un produit de condensation d'acide hydroxyacétique d'un poids moléculaire moyen compris entre 200 et 4 000, ledit produit de condensation pouvant être décomposé dans les conditions de la formation, grâce à quoi des monomères et des dimères d'acide hydroxyacétique sont formés, et ledit produit de condensation étant présent en une quantité efficace pour fournir une quantité suffisante de produits de décomposition, comprenant de l'acide hydroxyacétique, pour réagir avec le gel et rompre celui-ci dans ledit cake de filtration et rétablir la perméabilité dans ladite formation sans qu'il soit nécessaire d'ajouter un matériau séparé de rupture de gel après la formation dudit cake de filtration du type gel. 50

2. Procédé selon la revendication 1, dans lequel ledit gel est constitué d'hydroxyéthylcellulose.

3. Procédé selon la revendication 1 ou 2, dans lequel ledit produit de condensation de l'acide hydroxyacétique est un produit de condensation de l'acide hydroxyacétique avec jusqu'à 15 % en poids de composés de co-condensation contenant d'autre portions hydroxylés, d'acide carboxylique ou d'acide hydroxycarboxylique, est essentiellement cristallin à la température ambiante et à la température du forage de puits, et a un point de fusion d'environ 160 °C ou plus, mais suffisamment élevé pour empêcher le ramollissement ou la fusion pendant l'utilisation, est essentiellement insoluble dans ledit fluide de traitement et peut être décomposé, en présence d'eau à une température élevée, en monomères et dimères qui sont au moins partiellement solubles dans une huile ou dans l'eau.

4. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel ledit gel aqueux est complètement hydraté avant d'être combiné avec ledit produit de condensation.

5. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel ledit réducteur de filtrat est constitué essentiellement dudit produit de condensation.

6. Procédé selon l'une quelconque des revendications 1 à 5, dans lequel ledit produit de condensation est ajouté en une quantité d'au moins 1,2 kg/l de fluide de traitement.

7. Procédé selon l'une quelconque des revendications 1 à 6, dans lequel la dimension moyenne des particules dudit produit de condensation est de 10 à 50 micromètres.